

of sight of the viewer's eye 62. Beam splitter 66' reflects the non-visible measurement signal from accommodation monitoring device 68 into the eye and also reflects the measurement signal from the eye back into lens 70 of the accommodation monitoring device. Beam splitter 66 (or a cold mirror), which transmits the non-visible measurement beam, reflects light from large DOF display 54' into eye 62, enabling the viewer to superimpose the displayed images with real objects 75. (Emphasis added, applicants' specification, page 13, lines 1-9).

As highlighted by the underlined portion quoted above, the beam splitter (for example, the cold mirror) both transmits the non-visible measurement beam and reflects light from the large DOF display (for example, the image source) into eye 62. In this manner, the viewer can simultaneously view the real world scene and the image, because as highlighted in the italicized portion above, the displayed images are superimposed with real objects 75. In addition, although not explicitly stated in the text, but as evident in FIGURE 5, beam splitter 64 can also reflect light from a real world scene, i.e., light from real objects 75.

Applicants therefore respectfully request that the Examiner withdraw the rejection of Claim 41, since support for its recitation is clearly provided in applicants' drawings and the specification.

Claims Rejected Under 35 U.S.C. § 103(a)

The Examiner has rejected Claims 1, 2, 5-10, 12, 15, 17, 19-21, 24-29, 31, 34, 36, 38, and 41 under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent Publication No. 2002/0163482 (Sullivan) in view of U.S. Patent Publication No. 2003/0086062 (Shevlin). Applicants respectfully disagree with the above rejections for at least the following reasons.

In the interest of reducing the complexity of the issues for the Examiner to consider in this response, the following discussion focuses on independent Claims 1 and 20. The patentability of each remaining dependent claim is not necessarily separately addressed in detail. However, applicants' decision not to discuss the differences between the cited art and each dependent claim should not be considered as an admission that applicants concur with the Examiner's conclusion that these dependent claims are not patentable over the disclosure in the cited references. Similarly, applicants' decision not to discuss differences between the prior art and every claim element, or every comment made by the Examiner, should not be considered as an admission that applicants concur with the Examiner's interpretation and assertions regarding those claims. Indeed, applicants believe that all of the dependent claims patentably distinguish over the references cited. In any event, a specific traverse of the rejection

of each dependent claim is not required, since dependent claims are patentable for at least the same reasons as the independent claims from which the dependent claims ultimately depend.

Patentability of Independent Claim 1

Significant differences exist between the recited subject matter and the cited art, because the cited art does not teach or suggest that the image is displayed on a *large depth of focus* display, as recited in step (a) of the claim and does not teach or suggest displaying an image having an apparent focus plane that tracks the accommodation of the viewer, *based on the accommodation that was determined*, as recited in step (c) of Claim 1. Furthermore, the cited art teaches away from using a large depth of focus display.

Discussion of Step (a) in Claim 1

It is clear that Sullivan is NOT teaching the use of a *large depth of focus* display, as recited by applicants in step (a), but instead, only employs a narrow depth of focus display. The Examiner has indicated that Sullivan uses a large depth of focus display, as shown in Sullivan's FIGURE 1 and FIGURES 4-7, for displaying an image to a viewer on a large depth of focus display. But each of the image planes in FIGURE 1 actually indicate that Sullivan's invention is dependent on use of a narrow depth of focus display. In order to assist the Examiner in understanding why Sullivan is teaching a narrow depth of focus display, it may be helpful for the Examiner to consider the following remarks.

It is important to understand that the human eye cannot simultaneously bring distant and nearby objects into sharp focus on the retina (analogously, a conventional camera with a larger lens opening cannot simultaneously bring into focus near and distant objects). At a given instant in time, the eye can only bring objects at one distance into sharp focus, and there is a roll-off in focus for objects that are in front of or behind that "sweet spot" of focus — the farther an object is from that sweet spot, the more blurred will be its image on the retina. The term "*depth of focus*" (sometimes used interchangeably with the term "depth of field") is used in optics and vision science to describe how gradually or suddenly the roll-off in retinal image focus is, as objects are moved away from the sweet spot. In photography, the *depth of focus* of the camera is varied by adjusting the size of the aperture (i.e., the *f-stop*). Decreasing the aperture increases the *depth of focus*, and "pinhole" apertures that are 0.5mm diameter and smaller provide an effectively infinite *depth of focus* (wherein distant and nearby objects are both in focus). In contrast to a camera lens, the human eye has a narrow *depth of focus* under all natural viewing conditions, because its pupil (i.e., its aperture) cannot

1 constrict to a 0.5mm diameter. Thus, conventional video displays, such as LCD screens, are viewed
2 with a narrow depth of focus.

3 To give the eye a *large depth of focus*, it is necessary to “artificially” decrease the effective
4 pupil diameter by using a display that has a small “exit pupil.” As explained in applicants’
5 specification:

6 Some viewing conditions artificially increase the DOF of the eye. For
7 instance, if a scene is viewed through a small pinhole, then both distant and near
8 objects are in focus at the same time. Under such conditions, the negative feedback of
9 dioptric blur is removed or substantially decreased, and accommodation is said to be
10 “*open-loop*” (because the feedback loop is interrupted). Under open-loop
11 accommodation conditions, the viewer can accommodate from extremely near to far
12 without a significant change in the retinal image of the scene. Some video displays
13 can be made to have a very large DOF. As one example, the virtual retinal display
14 (VRD) described in U.S. Patent No. 5,467,104 can have a large DOF, producing an
open-loop accommodative response in users. Other large DOF displays can be
fabricated and methods presented in this document are applicable to all possible large
DOF displays. (See applicants’ specification, page 2, line 34-page 3, line 10.)

15 However, the display in Sullivan is NOT a large depth of focus display, but instead is a
16 narrow depth of focus display. Sullivan teaches:

17
18 Using the MVD system 10, the 3D images 34, 56 are generated to provide for *natural*
19 *viewing* by the viewer 12, that is *the 3D images 34, 56 have substantially all of the*
20 *depth cues associated with viewing a real object*, which minimizes eye strain and
21 allows viewing for extended periods of time without fatigue. (Sullivan,
paragraph [0172].)

22 As highlighted by the bold and italicized portions quoted above from paragraph [0172] of
23 Sullivan, Sullivan teaches that the images provide for natural viewing with all of the depth cues
24 associated with viewing a real object. Thus, there is no teaching that there is any configuration to
25 make Sullivan operate as a large depth of focus display (such as causing the viewer to view the scene
26 through a small pinhole). Sullivan does not teach or suggest any such approach. Instead, Sullivan is
27 completely configured for natural viewing with all of the depth cues present that are provided by a
28 narrow depth of focus display.

29 Furthermore, Sullivan recites subject matter in Claims 10 and 11 that indicates that the
30 approach used by Sullivan is directed toward a narrow depth of focus display. Notice that Claim 10

1 of Sullivan recites that the multi-surface optical device operates in a normal mode, such that each of
2 the plurality of optical elements is in a scattering state. In Claim 11, Sullivan recites that the multi-
3 surface device operates in a reverse mode such that each of the plurality of optical elements is in a
4 transparent state in the absence of an electric field, and in a scattering state in the presence of an
5 electric field. In other words, Sullivan teaches a stack of LCD shutters, each of which takes turns
6 acting as a projection screen that scatters light in many directions. Such scattering results in an exit
7 pupil larger than the entrance pupil of the viewer's eye, and thus produces a natural narrow depth of
8 focus.

9 In summary, Sullivan includes a stack of multiple narrow depth of focus displays, placed at a
10 number of different fixed focal lengths, which is unlike applicants' large depth of focus display that is
11 placed at only one fixed focal length.

12 Although the Examiner has not cited Shevlin as disclosing the recitation of step (a), applicants
13 would like to point out why Shevlin, in the alternative, also does not disclose the recitation of step (a)
14 in Claim 1. Shevlin indicates in several places that it is directed toward a narrow depth of focus
15 display, i.e., Shevlin indicates that it relies on a large exit pupil. For example, Shevlin indicates in
16 paragraph 0054, that the final optical system comprises a conventional low-aberration, wide field-of-
17 view eyepiece. This paragraph further explains that "it provides a Newtonian view (where light
18 passes through most of the eye's entrance pupil) of the image." Thus, Shevlin effectively teaches the
19 use of a narrow depth of focus display that corresponds to a large exit pupil. In contrast, a large
20 depth of focus display corresponds to a small exit pupil. Furthermore, Shevlin describes that an
21 advantage of his invention is its ability to stimulate accommodation optically through provision of
22 sufficient photons at appropriate wavelengths, with appropriate wavefront curvature, and with a
23 sufficiently *large exit pupil* (paragraph [0067], emphasis added).

24 Discussion of the Recitation of Step (c) in Claim 1

25 In order to illustrate and clarify the differences between the recited subject matter of step (c)
26 and the cited art, it may be helpful to consider a portion of an example set forth in applicants'
27 traversal of the Restriction Requirement, which was filed on 05/15/2007. Applicants' FIGURE 8 is a
28 flow chart showing the logic employed in the present approach to select and display an image with an
29 apparent focus plane that corresponds to a viewer's level of accommodation. The steps of this flow
30 chart are described on page 15, line 11, through page 16, line 6. More specifically, notice that step 80

1 explains that when a person views the display, the person's eyes accommodate and converge on an
2 element in the large depth of focus (DOF) display. The accommodation of the viewer's eye(s) is
3 measured in a step 82. Alternatively, the system measures the vergence (or gaze direction) of the
4 viewer's eyes in a step 82' (and can then optionally compute the accommodation power based on the
5 vergence) (see applicants' specification, page 15, lines 11-14). In a step 98, a new image with a best
6 focus plane that corresponds to a viewer's level of accommodation is shown. Thus, an example of
7 these steps incorporated in the recitation of step (c) would be:

8 displaying an image having an apparent focus plane that tracks the accommodation of
9 the viewer (i.e., step 98 (new image with a best focus plane)), so that as the
10 accommodation of the viewer watching the large depth of focus display changes (i.e.
11 step 80 (a person views a display, and the person's eyes accommodate and converge)),
12 the image that is displayed (i.e., a tree and house and driveway in the illustrated
example in FIGURES 2-7) is changed to more accurately convey depth in the image
that is displayed, *based on the accommodation that was determined.*

13 In contrast, the image that is displayed in Sullivan is NOT changed to more accurately convey
14 depth in the image that is displayed, based on an accommodation that was determined. Instead,
15 Sullivan uses hardware to convey the depth effect as illustrated in MOE device 32 that comprises a
16 stack of single pixel liquid crystal displays, as taught in paragraph [0068].

17 The Examiner has asserted that Sullivan discloses the recitation of applicants' step (c) in
18 Claim 1, because Sullivan teaches that the images on the large depth of focus display 36-42 varies,
19 i.e., changes, based on the accommodation of viewer 12 to more accurately convey depth in the
20 image that is displayed. In support of this assertion, the Examiner cites FIGURE 1 and
21 paragraph 0144 of Sullivan. Applicants respectfully disagree.

22 In the Abstract, Sullivan teaches that a substantially haze-free three-dimensional (3D) image
23 can be viewed on the multi-surface optical device (i.e., using specific hardware) in order to allow it to
24 be viewed from a wide range of viewing angles. But this statement does not mean that the image
25 itself is displayed differently on the multi-surface optical device when a user changes an
26 accommodation, or in other words, when a user views it from a different viewing angle or at a
27 different depth of focus in the image. Applicants have clarified this distinction in the amended
28 recitation of step (c) to make it clear that the actual displayed image itself is re-rendered, *based on*
29 *measuring the eye's accommodation.* Thus, step (c) has been amended to recite that the image is
30 displayed and that this change in the displayed image is based on the accommodation determined for

1 the viewer. Accordingly, the displaying performed by applicants' recited technique is unlike that
2 used by Sullivan's 3D display, which uses several surfaces at different depths (i.e., hardware) to
3 display the image. In other words, Sullivan teaches that depth can be adjusted by varying the
4 geometry of MOE device 32 (see Sullivan, paragraph 0147), including the number and spacing of the
5 plurality of optical elements 36-42.

6 There is No Suggestion to Modify the Sullivan Reference with the Shevlin Reference

7 As apparent from the above discussion, applicants have explained why the combination of
8 these references does not teach or suggest all of the recitation of Claim 1. Applicants also point out
9 that it is not obvious to modify the Sullivan reference with the Shevlin reference. With respect to
10 independent Claim 1, the Examiner asserts that Sullivan discloses focusing with respect to a viewer
11 who is watching the image on a large depth of focus display, and in support of his assertion, the
12 Examiner cites page 13, paragraph 0144 of Sullivan. The Examiner acknowledges that Sullivan is
13 silent in regards to the explicit step of determining an accommodation for an eye of the viewer and in
14 regards to tracking an accommodation of the viewer. But, the Examiner asserts that Shevlin teaches
15 this step and cites to FIGURE 1 and page 2, paragraph [0028], wherein the Examiner indicates that
16 Shevlin teaches an eye tracking system for monitoring the look direction and accommodative state of
17 a viewer. The Examiner concludes that it would have been obvious to one having ordinary skill in
18 the art at the time the invention of the present application was made to modify the display system of
19 Sullivan in accordance with the teaching of Shevlin, to use an eye tracking system for monitoring the
20 look direction and accommodative state of the viewer, in order to simulate a wide field of view, high
21 resolution color scene, with low aberration, and thus to optically stimulate the user's accommodative
22 system, as suggested by Shevlin on page 1, paragraph 0011, lines 6-9.

23 First, in an effort to clarify the different terms, large depth of focus and narrow depth of focus,
24 applicants respectfully point out that "wide field of view" should not be confused with "large depth
25 of focus" because field of view refers to width and height of the image, while depth of focus refers to
26 the total distance within a scene at which both near and far objects are in focus.

27 Second, the Examiner should note that both references are directed toward a narrow depth of
28 focus display. In contrast, the recitation in Claim 1 is directed to a large depth of focus display.
29 Thus, applicants submit that both the Sullivan reference and the Shevlin reference teach away from
30 the recitation in Claim 1, because they teach away from using a large depth of focus display.

1 Accordingly, Sullivan in view of Shevlin does not teach or suggest all of the recitation of Claim 1,
2 and the rejection of Claim 1 as being unpatenable over Sullivan in view of Shevlin should be
3 withdrawn.

4 Since dependent claims inherently include all of the recitation of the independent claim on
5 which they ultimately depend, the rejection of dependent Claims 2, 5-10, 12, 15, 17, and 19 should
6 also be withdrawn, for at least the same reasons as noted above in connection with independent
7 Claim 1.

8 Patentability of Independent Claim 20

9 Independent Claim 20 is directed toward a system for more accurately conveying depth in an
10 image. The Examiner has rejected Claim 20 for reasons similar to those given for the rejection of
11 Claim 1. Subparagraphs (d)(i) through (d)(iii) of Claim 20 are generally similar to the steps of Claim 1,
12 subparagraphs (a) through (c). Applicants have amended subparagraph (d)(iii) to recite that the image is
13 displayed, *based on the accommodation that was determined*, and the claim already recites a large depth
14 of focus display. Thus, applicants respectfully submit that for the reasons given above in their traversal of
15 the rejection of Claim 1, significant differences exist between the recited subject matter and the cited
16 art, because the cited art does not teach or suggest displaying an image having an apparent focus
17 plane that tracks the accommodation of the viewer, based on the accommodation that was determined
18 as recited in subparagraph (d)(iii). In addition, the cited art does not teach or suggest that the image
19 is displayed on a large depth of focus display, as recited in subparagraph (d)(i). Furthermore, the
20 cited art teaches away from the recited subject matter, since the cited art is directed toward the use of
21 a narrow depth of focus display – not a large depth of focus display.

22 Accordingly, Sullivan in view of Shevlin does not teach or suggest all of the recitation of
23 Claim 20, and the rejection of Claim 20 as being unpatenable over Sullivan in view of Shevlin should
24 be withdrawn.

25 Since dependent claims inherently include all of the recitation of the independent claim on
26 which they ultimately depend, the rejection of dependent Claims 21, 24-29, 31, 34, 36, 38, and 41
27 should also be withdrawn, for at least the same reasons as noted above in connection with
28 independent Claim 20.

1 Discussion of Patentability of Dependent Claims

2 The Examiner has also rejected Claims 3, 16, 18, 22, 35, 37, 39, and 40 under
3 35 U.S.C. § 103(a) as being unpatentable over Sullivan in view of Shevlin, and further in view of
4 U.S. Patent No. 6,449,309 (Tabata). Additionally, the Examiner has rejected Claims 4, 11, 13, 14,
5 23, 30, and 32-33 under 35 U.S.C. § 103(a) as being unpatentable over Sullivan in view of Shevlin,
6 and further in view of U.S. Patent No. 6,133,944 (Braun et al.). However, because dependent claims
7 are patentable for at least the same reasons as the independent claims from which they depend, the
8 rejection of Claims 3, 4, 11, 13, 14, 16, 18, 22, 23, 30, 32-33, 35, 37, 39, and 40 should be withdrawn
9 for at least the same reasons as the rejection of those independent claims.

10 Based upon the preceding Remarks, it should be clear that all claims remaining in the present
11 application are patentable over the art cited. This case should thus be passed to issue without further
12 delay. In the event that any question remains, the Examiner is asked to telephone applicants' attorney
13 at the number listed below.

14 Respectfully submitted,

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